The Chemical Age

A Weekly Journal Devoted to Industrial and Engineering Chemistry

VOL. LIII
No. 1363

SATURDAY, AUGUST 11, 1945
REGISTERED AS A NEWSPAPER

6D. PER COPY
POST FREE 8D.

The Chemical Age

A Weekly Journal Devoted to Industrial and Engineering Chemistry

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VOL. LIII No. 1363. — August 11, 1945 — Annual Subscription 21s. Overseas 26s.

National Research

LORD LEVERHULME, from his vast experience of industrial research and of the application of research to industrial processes, gave the Society of Chemical Industry some wise comments and advice upon the organisation and development of research, in the course of his delivery of the Medallist's Lecture. A great deal of planning is taking place all over the country; and it is often difficult to distinguish between planning and regimentation. The seeming efficiency of a totalitarian State seems to have deluded the civilised world into believing that that is the way in which mankind should organise itself. Government controls, Government orders, the slavish search for efficiency at the expense of human freedom, are all disturbing elements in our present civilisation. We trust that this phase will pass, for if it does not, individual liberty will pass. As we heard Lord Leverhulme speaking on the organisation of research, our mind went to the scholarship of universities, to the scholarship of quiet minds, who, like Newton "voyaged through strange seas of thought alone," individualistic minds that, without premeditation or the hope of gain, have, by giving thought, added many cubits of stature to the human race. The realisation of how much would be lost if the planners were to have their way unchecked fell upon our consciousness like a hammer-blow. Planning is necessary as a tool towards efficiency, but it must be kept in its proper place *as a tool* and must never be allowed to become our master.

Lord Leverhulme was emphatic that we do not want a national research blueprint, that we must not regiment our scientific workers. He agreed with the view that if research is to be successful it must be well managed, but good management is not to be confused with regimentation. Sometimes it is good management of a spirited horse to let him have his head. So is it also good management of a research worker to let him pursue whatever course seems good to him even if it means putting others to work on the problem in which he was initially engaged. The successes of unplanned research have been many and great. When Becquerel discovered the penetrating power of X-rays he did not foresee the uses to which they would be put, nor was he

On Other Pages

engaged in a search for a method of securing those objectives which we can now reach through X-rays. Fleming's discovery of penicillin was equally an unplanned result of reseach leading to unsuspected results. So also have been many others of our great achievements in the realm of discovery.

We have often unthinkingly assumed the Law of Supply and Demand, that the words "supply" and "demand" are supposed to follow one another as a natural consequence. So they do, but not in the way in which most people think. We have been accustomed to supplying a demand. Merchants will say that their stocks remain unsold because there is no demand and therefore they themselves refrain from buying from the manufacturer. Thus, in the working of the law of supply and demand, the "demand" has always been assumed to govern the "supply." Lord Leverhulme has pointed out that in industrial science the reverse is more usual, and that in many instances demand has not arisen until it has been created by the existence of supply. Thus the public had no desire for the gramophone, for wireless sets, for the cinema, for television, for a host of other things, until science had discovered how these things were to be made and thereby created the demand. Industrial research must clearly be directed largely to discovering uses to which scientific discovery can be put in order to create a demand.

This principle is very important for the future of this country. Our staple lines of manufacture will not be required abroad to anything like the extent that they once were. Other nations are setting up their own iron and steel works, their own textile manufactures and so forth. We shall be driven to supply the world with new things that it cannot manufacture for itself. The law of supply and demand will govern our exports in the future as it has done in the past. It is for us to create the demand.

The war has shown the importance of research teams and of how great problems can be solved by intensive research in which many individuals take part. This type of research is suited to some minds, but it is not the best way of using all research personnel. It is by no means certain that a research team in the accepted sense of the term should be built up by advertisement and appointment. The ideal team would be a body of enthusiasts gathered voluntarily (which does not mean unpaid) around an outstanding figure who would act as their director. Unfortunately, such outstanding figures are not numerous, but we believe that this country will always produce them in sufficient quantity and of sufficient quality when the need is generally understood.

The Government, in Lord Leverhulme's view, should not plan research. The present insistence on avoidance of overlapping is not, in his view, well founded. That one man or one team of men is working on a particular subject is no reason why another man or, indeed, many other men, should not be working on the same subject. One man does not necessarily discover all that there is to be known about the subject on which he is working and, since the human mind is capable of many shades of thought, it is better that several men should work independently on a problem which one of them would ultimately solve than that the problem should possibly remain unsolved through fear of overlapping. The Government should aim at encouraging research, it should aim at stimulating research, and it should give assistance to research, but it should not presume to dictate what research shall be carried out nor by whom. Among the methods of stimulation of research not the least is relief from taxation. The Government must undertake certain research work directly, *e.g.*, research into defence methods, research into health, and such research into the utilisation of our national resources as is not suited to be carried out by industry. There should also be, in Lord Leverhulme's view, more closely organised contact between universities and industry since each can gain a good deal from the other. Industrial research as visualised by him follows the general principles laid down by Sir Harold Hartley in his now well-known pamphlet "Are You Research Minded?" We think nothing more need be added on that score.

One final word, however, refers to the place of the research man in the higher councils of industry. Professor Rideal

pointed out that whereas industrial factories were at first owned by practical chemists, the higher direction here has now become divorced from the practising chemist; whereas in the U.S.A. and in Germany the practising chemist ranks high on the industrial directorate. In his view the absence of the chemist from the board in any industry spells the death of that industry. Lord Leverhulme was emphatic in stating that the head of the research department should always be on the board of his concern. Frankly, we have been disturbed by some of the tendencies that we have observed. There are still far too many instances of men being put on the board for reasons other than the value of the knowledge and experience which they can bring to the affairs of the company. It may be that a revision of our practice of making appointments to boards of directors, permitting a larger representation of scientific and technical knowledge, will prove to be the greatest single contribution to industrial efficiency and progress that could be made in this country.

NOTES AND COMMENTS

The Atomic Bomb

ATOMIC energy has at last been released on a large scale. Unhappily, it is as a destructive weapon that this power has been used in the first place; but as the weapon is turned against the last of the wilfully destructive warmongers, we may surely hope before long to see this unlimited power diverted into constructive channels: such a prospect has, indeed, been forecast. It is early yet to give detailed editorial consideration to this tremendous potentiality for good or evil that science has put into human hands: but we can trace the romantic history of its development from the theoretic to the practical stage. Much, indeed, has happened since vague disquieting rumours were circulating in the popular Press in 1940 concerning the atom-splitting powers of "uranium 235"—the uranium isotope with atomic weight 235. It was then stated, probably with truth, that German scientists had received orders to go "all out" on research into this material. Happily, our own scientists, with those of the U.S.A. and Canada, were able to outstrip them (as usual); and it is into the hands of the protectors of the rights of man that the weapon has fallen. Active research on the project was initiated as early as 1939, and by 1941 substantial progress had been made. There is no space here to fill in all the detail; but some of the salient steps in the story must be recorded. A team of workers, under the supervision of Sir George Thomson, working in university laboratories, at the D.S.I.R., and in industrial establishments, laid the foundations. Sir John Anderson was finally responsible for the co-ordination of the work of all the technical committees concerned; and so well did he do the work that he was specially asked to continue even after he became Chancellor of the Exchequer.

"Tube Alloys"

MEANWHILE, the business was becoming too big for our small and vulnerable island. Throughout we had kept the United States authorities advised of what was going on, and from 1941 British and American efforts were conjoined and a number of British scientists proceed to the U.S.A. Under the direction of Mr. W. A. Akers, of I.C.I., a special division within the D.S.I.R. had been set up, known, for "hush-hush" reasons, as the Directorate of Tube Alloys," as well as a technical committee (also under Mr. Akers) composed of Sir James Chadwick, Professor Peierls, and Drs. van Halban, Simon, and Slade, joined later by Sir Charles Darwin and Professors Cockcroft, Oliphant, and Feather. It is worth noting that Peierls and Simon were Jewish savants who had been driven from Germany as "not required." Meanwhile, the Germans were carrying on with similar research; and to checkmate them two commando raids were made on the Norsk Hydro works at Vemork, the sole source, in Germany, of heavy water, an essential material for one of the methods of releasing atomic energy. The second of these raids was completely successful. Just

to give ourselves added confidence, Professor Niels Bohr, the world-famous physicist, was "kidnapped" from Copenhagen, and, through the good help of Sweden, was preserved from German interference. From the far north of Canada the Eldorado Mining and Refining Company at Great Bear Lake provided uranium ores for the working of the process, and special arrangements were made to ensure that all supplies of uranium were earmarked for the exclusive use of the Crown. Patent control has been secured in the U.S.A., U.K., and Canada to make certain that the weapon cannot fall into the hands of the enemy. A most effective test was carried out in the wilds of New Mexico last month, and on Monday of this week, a bomb, more powerful than 20,000 tons of TNT, was dropped on the Japanese base of Hiroshima. At the time of writing, impenetrable clouds of dust still veil the effects of this devastating weapon.

Success at Potsdam

THE official 6000-word document, issued after the Tripartite Conference of Potsdam—the first international document signed by the new Prime Minister—is an admirable catalogue of principles, moral, political, and economic, which, if carried out, may put an end to the scourge of recurrent German aggression. Stern retributive measures are to be taken against Germany and against the German people, but there is a commendable absence, in the document, of any dramatic *væ victis* attitude. The danger that Germany would be split into differently administered zones, inviting a host of unpleasant consequences, has happily been avoided, as uniformity of treatment has been decided throughout Germany, where militarism and Nazism will be extirpated. Somewhat late in the day, the decision has now also been made to remove members of the Nazi party from public, semi-public, and important private posts. One of the most significant decisions is that the political structure will be decentralised and the development of local responsibility, mainly in the form of local self-government—in which Germany has had mighty little experience—promoted.

German Economic Eclipse

GERMAN economy is to be decentralised so as to eliminate the present excessive concentration of economic power in cartels, syndicates, trusts and other monopolistic arrangements. It may be assumed that in the drafting of this clause, U.S. experience in anti-trust legislation has stood in good stead. Germany is to be completely disarmed and demilitarised, and all industry that could be used for military production will be eliminated or controlled. The importance of the chemical industry for good or evil has been recognised, and chemicals are, in fact, mentioned twice in the text. In order to eliminate Germany's war potential, armaments production will not merely be prohibited, but also its revival will be prevented. Production of metals, chemicals, machinery, and other items essential to a war economy will be rigorously controlled and restricted to approved peacetime needs. Excessive productive capacity will either be removed under the reparations plan, or else destroyed. However, agriculture and peaceful industries (it is hoped a more precise definition will be found soon), are to be encouraged.

Reparations

THIS time there is going to be no repetition of the unworkable reparations scheme of Versailles. The simple principle has now been accepted that reparation claims of the U.S.S.R., the U.S., and the U.K., will be satisfied from their respective occupation zones, Russia will receive 15 per cent. of industrial capital equipment situated in the Western zone, derived, in the first place, from the metallurgical, chemical, and machinery industries. In exchange, the U.S.S.R. will supply an equivalent value of food and of raw materials, including oil and metals. A further 10 per cent. of industrial plant shall similarly be transferred without any return in kind. This transfer, to be completed within two years, is a major development and is bound to lead to significant changes in world economy. It spells the end of Germany as a leading industrial power and heralds a large-scale development of the vast territories of Eastern and South-Eastern Europe.

The Mixing of Solid Particles*

The Application of Theory to Practice

by P. M. C. LACEY, B.Sc., A.C.G.I., D.I.C.

THE mixing of solid materials in the dry state is a purely mechanical operation, but it is of great importance in a large number of chemical engineering processes.

There are three main reasons for requiring a very intimate mixture of solids. Firstly, the materials being mixed may subsequently be required to react chemically with one another—*e.g.*, in dry explosives. Secondly, the mechanical properties of the final product may depend on the spatial configuration of the various particles, as in the case of aggregates for concrete. Thirdly, it may be desired to take from the mixture samples which can be relied upon to contain a fixed proportion of each constituent; an outstanding example of this is the production of pills and medicinal powders.

Such processes have been carried out since the earliest times and a good deal of work has been done on them, but in all of it there seems to have been a complete avoidance of anything at all fundamental. The large amount of literature on the subject confines itself almost exclusively to the patenting of designs for mixing machines, but nothing quantitative is said about the performance of these machines. It may well be that manufacturers have done fundamental work, but have decided not to publish the results. On the other hand, the avoidance of fundamentals is rather to be expected, for two reasons: (i) mixing depends in practice to a very great extent on local conditions and materials; and (ii), although the superficial theoretical problems that arise are of a very elementary and obvious nature, as soon as fundamentals *are* considered the subject at once becomes complex and elusive in nature. If, however, co-ordination of work and simplification of problems in mixing are to be brought about, the fundamental nature of the operation must be clearly understood; and at present there is in existence not even an acceptable definition of degree of mixture.

Definition of a Mixture

The only discoverable definition of any sort is for a perfect mixture. It is due to Professor Ure and may be written as follows: "If a given mixture of materials is such that the compositions of all samples taken from it, however small, are identical, then the materials are perfectly mixed." But even this obviously cannot apply to solids since, to take the matter to extremes, the composition cannot possibly be right when one gets down to a sample so small that it contains only one particle.

There are, indeed, two important differences between the mixing of fluids (in which virtually perfect mixture is attainable) and the mixing of solids. In the first place the particles in a fluid are of molecular size, so that the smallest samples that can be taken in practice still contain many millions of them—many more particles than would be present in a similar sample of the most finely ground solid material. The effect of this on the constancy of sample composition is fairly obvious and will be demonstrated mathematically later on. The second difference lies in the intrinsic mobility of the molecular particles in fluids, which, if given the chance, will eventually mix themselves without any external aid, while a little stirring will complete the process in a relatively short time; whereas solid particles not only have no mobility of their own, but exert considerable frictional forces on each other which retard their being mixed by an external agency. The fact that the particles in samples from a mixture of solids are so much larger and fewer makes it necessary to consider such mixtures from the point of view of individual particles.

Variation of Composition

In any mixture of discrete solid particles it will be found that the compositions of samples taken from it are not constant, but vary round a mean value. This variation occurs over a fairly confined range for samples of any given size, and if smaller samples are considered, although the variation becomes intrinsically less, it becomes proportionally more important. This applies even to a very good mixture, but the range of the variations is not large enough for them to be observed except in fairly small samples; in a bad mixture the range is much wider, and the variations become apparent in comparatively large samples.

Although in a mixture of solids it is therefore impossible to eliminate variations in sample composition, there must be some best obtainable mixture—conveniently described as the "ideal mixture"—in which there will be the minimum variation in composition at any given sample size.

Before proceeding further with the variation in composition it will be as well to get a clearer picture of that composition itself, and perhaps this is suggested by the word "dispersal": in a good mixture the particles of one material are evenly dispersed among those of another material, and we

* Paper delivered to the Graduates' Section, Institution of Chemical Engineers, February 26, 1943. Owing to the author's severe illness, from which he has happily recovered, the completion of the MS for press, has been delayed.

may tentatively define "degree of mixture of solids" by the phrase "degree of dispersal of like particles throughout the mixture."

It is essential to look at the matter from this point of view rather than to think of materials being mixed *with each other*, otherwise anomalies arise when considering mixtures of more than two components. Consider, for instance, a good mixture of materials A and B, and a good mixture of A and C, each mixture containing the same proportion of A; if these two mixtures are *very roughly* blended, the A-particles will still be evenly dispersed everywhere, but both the B- and the C-particles will be badly dispersed: hence it can no longer be said that the A's and the B's are well mixed, nor the A's and the C's, although they were so before, and although the distribution of the A's still corresponds to that in a very good mixture. Each component should therefore be considered separately. It is, however, always permissible to ignore one component, since its distribution is known if those of all the other components are known.

The "ideal mixture" may now be considered in more detail. It may be visualised as a very evenly dispersed system of one kind of particle, with the other kind or kinds filling up the intervening spaces. One can easily imagine examples of such a system: in Fig. 1a a mixture is illustrated

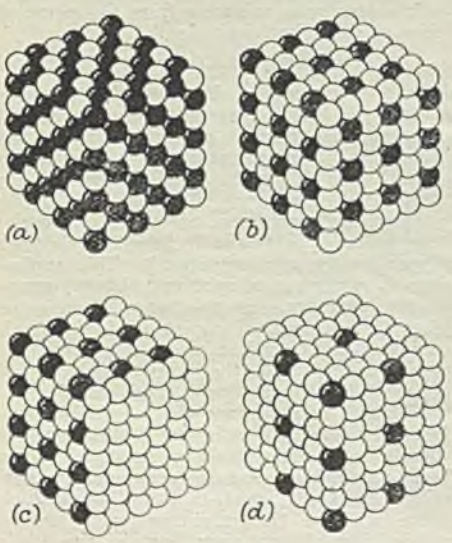

Fig. 1.

consisting of black and white particles in equal proportions; in Fig. 1b the proportion is one in four; in Fig. 1c one in eight; in Fig. 1d one in 27, and so on.

Now, any such mixture is a complex arrangement which would have to be built up carefully, and it would lose its form as soon as one started to stir it. But stirring is the very essence of mixing operations; it creates *disorder*, allowing chance to determine the positions of the particles. When starting to mix from zero, one has the particles arranged in a definite order—a heap of each, say—and then the machine does certain fairly definite things with them. But each time the machine acts on a particle a certain amount of chance is introduced, and, as mixing proceeds, the chance effects continually accumulate until they completely outweigh any direct effect of the machine itself. Eventually an equilibrium state is produced, in which disorderliness is at a more or less stable maximum. (It is to be noted that the phenomenon sometimes encountered in which the particles tend to become resegregated when they have been mixed for a while is a separate effect due to differences in size, weight or shape of the particles.)

The Manufacturer's Ideal

This equilibrium state is the maximum extent of mixing obtainable from a mixing machine, and is the ideal for which the manufacturer of the mixture strives. On the other hand the ideal mixture for the man who is going to use it is obviously the one that conforms to the condition of true maximum dispersal illustrated in Fig. 1.

But what sort of a mixture is it that one dare not disturb because it will unmix itself if one does? Clearly, only the disorderly one need be considered, and it may be defined as follows: In an ideal mixture of solids the degree of dispersal of the components is the one most likely to exist in a mixing machine after equilibrium has been established.

In such a mixture the precise arrangement of particles will vary with every turn of the mixing machine; but a great majority of these arrangements will give similar results when the mixture is analysed by sampling. It must be emphasised that it is still possible for arrangements to occur, purely by chance, which give results different from the above on analysis, and in an extreme case, for instance, it is possible for a condition of true maximum dispersal (*e.g.*, as in Fig. 1) to exist momentarily in a mixing machine, though it is highly improbable. This equilibrium is much more like the usual kind of vapour-liquid equilibrium than might at first appear. In the latter case there must at some moments be more molecules leaving the surface of the liquid than are entering it, and at others the reverse; but the most frequent or most probable condition, in which equal numbers are leaving and entering, is the only one that need normally be considered.

Suppose the particles in a mixing machine, of which, say, half are black and half white,

are stirred for a long time—long enough to produce this equilibrium condition. Then if any particular point in the machine is examined to see which kind of particle is

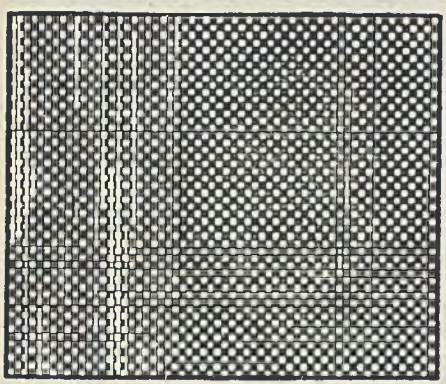

Fig. 2.

there, there will be a 50 per cent. chance that it is black and a 50 per cent. chance that it is white. Suppose it is a black one.. Then if a point next to it is examined one is not bound to find a white one there, as is the case in Fig. 1a; the same 50-50 chance exists, and one is just as likely to find another black one; and this applies to all points in the mixture. However, although the arrangement of the particles at any moment is entirely the result of chance, mathematical methods of analysis can be applied to the system to give a sensible answer. The starting point is this: the probability of finding a particular kind of particle at any point is a constant, equal to the proportion of that kind of particle in the whole mixture.

Before proceeding to the mathematical argument it will be as well to consider a pictorial representation of the ideas involved. If one mixes equal quantities of black and white particles very thoroughly one may hope to obtain the kind of arrangement shown in Fig. 2, whereas Fig. 3 shows the best one is likely to achieve—the ideal mixture. (Fig. 3 was made by a process equivalent to tossing a coin for each square in turn, and colouring the square black if it turned up "heads.") It will be observed in Fig. 3 that there are some very large groups of black particles; and, indeed, this is to be expected, since in a mixing machine black particles will be thrown against black particles just as often as against white ones. It will be seen, too, that there are occasional tendencies to form part of Fig. 2. In fact, there are tendencies to form somewhere parts of any imaginable arrangement.

If the squares in Fig. 3 are counted it will be found that there is not exactly the same number (1500) of each, but a slight excess (16) of white ones; and if the whole diagram were made up again there would probably still not be exactly 1500 of each.

Fig. 3.

But if the process were repeated several times the number of whites in each count would group themselves about 1500 as in the frequency curve shown in Fig. 4. (This approximates to the Gaussian normal curve of error.)

Let us now consider the problem of investigating a given mixture. Our criterion of mixedness being the variation of sample composition, we must clearly take samples. There are two ways of doing this; either the choice of samples must conform to the recognised method of random sampling, or

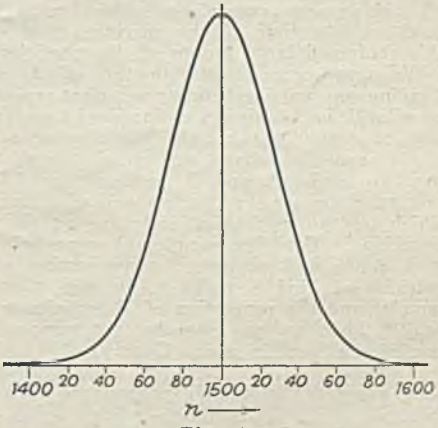

Fig. 4.

else the whole material must be divided up into samples. Random sampling, however, only gives an approximation, based on probability, to the results which may be expected from dividing up the whole mixture. And in an investigation such as the

one to be described, where an actual theory is to be tested and the greatest accuracy is required, one has to carry out the more laborious operation; and in the theoretical work which follows it will normally be assumed that this has been done.

When dealing with a mixture of two components only one of them need be considered, and the composition of any sample will be expressed by the proportion of that component in it. The variations in composition of all the samples round their average composition will be investigated, but only one size of sample will be considered at a time since, as already pointed out, the smaller the samples taken the greater the variability that will be found among them. These variations among samples of any given size will then be expressed by the quantity known as the Standard Deviation, *i.e.*, the root-mean-square of all the individual deviations from the mean composition. This will be called σ, which will be an inverse function of n, the number of particles in a sample.

It must always be remembered that if the mixture were divided up into samples of a different shape, though still of the same size, the same value of σ would not necessarily be obtained. But if it were divided up in a number of different ways, covering the various possible shapes of sample, the results would group themselves round some central value of σ which could be taken to apply to the mixture itself, rather than to a particular collection of samples. Change of shape of sample would probably have a fairly large effect: to take an extreme example, if samples were taken in the form of thin laminæ one might obtain quite a good cross-section of the mixture even if this contained large groups of like particles.

We may now investigate the effect of dividing up an ideal mixture: what value of σ will be obtained? Suppose, for the sake of simplicity, that the particles are all of the same size, shape, and weight, so that the two kinds, A and B, can only be distinguished by some property, such as colour, which has no mechanical influence on their behaviour. Consider samples of n particles at a time; and suppose the proportion of particles of kind A to be α, in any given sample, and the proportion of B-particles to be β. Then we may say that the composition of that sample is α. Clearly

$$\alpha+\beta=1 \quad \text{.....} \quad (1)$$

Now suppose the overall proportion of A-particles in the whole mixture to be $\bar{\alpha}$, and of the B-particles $\bar{\beta}$; then $\bar{\alpha}$ and $\bar{\beta}$ are the mean values of α and β for all the samples: and

$$\bar{\alpha}+\bar{\beta}=1 \quad \text{.....} \quad (2)$$

Next consider a single sample of n particles. If α is the proportion of A-particles, the number of A-particles must be αn; and this can have any of $n+1$ values from 0 to n according to the sample constitution. In the hypothetical analysis of the mixture the samples obtained can be divided up into groups according to the number of A-particles in them. Let P be the proportion of these samples containing any given number of the A-particles, so that there is a value of P for each value of α or αn, and $n+1$ values in all, whose sum must come to unity. Then, as $(\alpha-\bar{\alpha})$ is the deviation in composition from the mean, and σ is the root-mean-square deviation, we have:

$$\sigma=\sqrt{\sum_{\alpha n=0}^{\alpha n=n}(\alpha-\bar{\alpha})^2.P} \quad \text{.....} \quad (3)$$

In the case of the ideal mixture, which we are considering, an expression can be evolved for the value of P (for any value of α) which will most probably be obtained. It may be derived from first principles by considering the probability of obtaining a sample containing $n\alpha$ A-particles and $(n-n\alpha)$ B-particles.

$$P=\frac{\left(\frac{1-\bar{\alpha}}{\bar{\alpha}}\right)^{n-n\alpha} n!\,(\bar{\alpha})^n}{(n\bar{\alpha})!\,(n-n\bar{\alpha})!} \quad \text{.....} \quad (4)$$

This expression may now be substituted for P in equation (3), giving

$$\sigma=\sqrt{\sum_{\alpha n=0}^{\alpha n=n}\frac{(\bar{\alpha})^n(\alpha-\bar{\alpha})^2\left(\frac{1-\bar{\alpha}}{\bar{\alpha}}\right)^{n-n\alpha} n!}{(n\bar{\alpha})!\,(n-n\bar{\alpha})!}} \quad (5)$$

and it may be shown that this can be reduced to

$$\sigma=\sqrt{\frac{\bar{\alpha}\bar{\beta}}{n}} \quad \text{.....} \quad (6)$$

If we are given an actual mixture which has been stirred for a very long time, *i.e.*, an "ideal mix," in which chance is the only factor determining the positions of the particles, and if it is divided up into a series of samples of n particles each and σ then calculated for it, then the value shown in equation (6) is the one which is *most likely* to be found. As mentioned before, by pure chance one may get any sort of mixture, but some sorts are vastly more probable than others, and these are the ones which will give values of σ close to the theoretical.

It seemed advisable, however, to calculate what order of probability exists that a bad mixture will be obtained, that is to say a wrong value of σ, from a very thoroughly mixed material. It proved extremely difficult to calculate the formulæ for the probability curves, but this was achieved for the simplest possible case, in which only

samples of two particles are considered, and this sufficed to show the general trend. A pair of curves constructed from this formula are shown in Fig. 5. These represent a particular case, that of a half-and-half mixture (so that the maximum value of deviation is 0.5), and for samples in which $n=2$. Values of σ are plotted along the base, and the peaks show the theoretically most probable value, which in this case is 0.354.

The important point is that a different curve is obtained for each total amount of mixture, and the larger the mixture the greater is the probability that the theoretical value of σ will be found. Each of the two curves shown in Fig. 5 encloses the same area, representing unit probability. The first one is for a mixture of only a

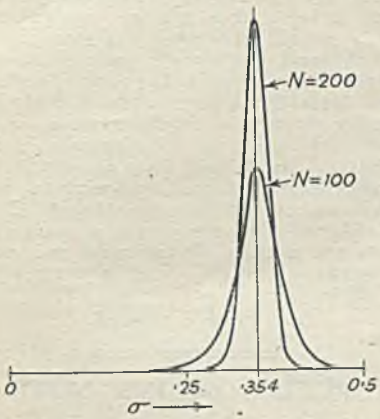

Fig. 5.

hundred particles in all, and the second of two hundred particles, which is still, of course, an extremely small number; two million is a much more likely quantity, and the peak in this case would become so large that it could not be represented on this sort of graph at all. The significance of this is that in practice one need not worry about getting a bad mixture by pure chance after the materials have been mixed for a long time; and in such well-mixed materials the theoretical value of σ will almost certainly be obtained if an analysis is made.

Now the expression for σ was evolved in an attempt to evolve a mixing index. But it can be seen from equation (6) that σ will not do in its present form. For one thing, it depends upon n, the size of the samples. This is a term introduced by one's method of analysis, and has nothing to do with the mixture itself. Moreover, it is desirable that the expression for mixing index should be independent of the particular over-all composition of the mixture, here represented by $\bar{\alpha}$, for the mixing machine cannot differentiate between mixtures of different compositions. So it seemed that a truer expression might be obtained if the experimental value of σ were divided by $/\sqrt{\bar{\alpha}\bar{\beta}}$ to allow for the effect of composition, and multiplied by $\sqrt{n}$ to allow for sample size. The latter device is perfectly sound statistically; the use of $/\sqrt{\bar{\alpha}\bar{\beta}}$ is perhaps rather doubtful, and it has not yet been possible to check whether this does in practice eliminate the effect of changes in over-all composition. These operations, of course, merely amount to dividing the value found experimentally by the theoretical value for the "ideal mix," giving as a provisional mixing index:—

$$\sigma \frac{\sqrt{n}}{\sqrt{\bar{\alpha}\bar{\beta}}}, \text{ or } \sigma \Big/ \sqrt{\frac{\bar{\alpha}\bar{\beta}}{n}} \quad \ldots\ldots\ldots\ldots\ldots \quad (7)$$

This should be unity if the material has been ideally mixed. But if the mixture has not reached this stage there will be more variation between samples, σ will be larger, and so this new expression will be greater than unity. It is desirable, however, that any expression for the mixing index should be less than unity for a mixture which is incomplete, and so it seemed that the above expression might be more useful in the form of its reciprocal:—

$$M = \sqrt{\frac{\bar{\alpha}\bar{\beta}}{n}} \Big/ = \sigma \sqrt{\frac{\bar{\alpha}\bar{\beta}}{n\sigma^2}} \quad \ldots\ldots\ldots \quad (8)$$

It is at this stage that we come across the real peculiarities of partial mixture. For, consider the worst possible case, the materials being completely separated. If this is examined on theoretical grounds it will be found that σ must equal $\sqrt{\bar{\alpha}\bar{\beta}}$, and if this value is substituted in equation (8) it is found that:—

$$M = 1/\sqrt{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

That is to say, M would be solely a function of the method of analysis, so that it could hardly be used to describe the mixture.

Mixtures of Groups

Trouble of a rather different kind is encountered when another special type of mixture is considered, that is to say, one which consists of little groups of like particles, the two different kinds of *group* being well mixed with one another. This is a case quite likely to arise in practice; before two materials to be mixed are brought together there are likely to be local agglomerations of particles, especially if they are damp, and unless the machine is constructed so as to break them up these will tend to behave like large particles. If this sort of mixture were analysed, it might well be found that, although fairly big samples gave a value of σ very close to the theoretical, small samples, which might quite possibly be drawn almost entirely from one little agglomeration or another, gave much too large a value of σ. This would mean that the smaller the sample the worse would be the mixing index. Of

course, all mixtures appear to be worse mixed the more closely they are examined, but in this particular case the apparent degree of mixture would deteriorate at a greater rate than normal. It is to be noted, however, that this apparent deterioration is not entirely a result of the method of expressing M, but partly a property of this particular mixture. On the other hand, the same cannot be said of the non-mixture; however closely it is examined the material is definitely unmixed, and M should be zero and not $1/\sqrt{n}$.

This raises the important question: Can the state of a mixture be adequately expressed by a single number? The more one considers the problem the more one is driven to the conclusion that it cannot.

Approaching the question from a rather different point of view, however, we see that the properties of the non-mixture suggest a new method of comparison for partial mixtures. In the ideal mixture the value of the expression for M (equation 8) remains constant (at unity) as the sample size, n, decreases; in the *non*-mixture it does not, but it falls off in value in a standard way, that is, inversely as $\sqrt{n}$. Presumably, in the intermediate mixtures it will fall off in intermediate ways, and we may be able to

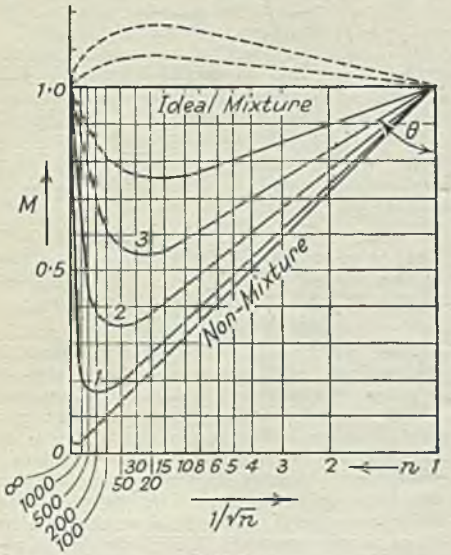

Fig. 6.

define the degree of mixing by the *way* the value of M falls off. This is illustrated in Fig. 6. Here, M is plotted against the sample size, n, as base; but as n will generally be fairly large it has been scaled as a reciprocal, and to simplify the diagram still further the reciprocal of $\sqrt{n}$ has been used. For the ideal mixture M remains constant at unity. When $n=1$, that is to say, when a mixture is analysed by taking samples of one particle at a time, the same value of M is obtained from the non-mixture as from the ideal one; obviously, one cannot find out anything at all about the state of a given mixture if one only examines it particle by particle. When n is large, M for the non-mixture clearly becomes very small, and zero in the limit (*see* equation 9). This shows the advantage of the reciprocal root base, for the graph for the non-mixture becomes a straight line at an angle of 45°. For intermediate mixtures we should expect curves such as those indicated in the diagram; now, although these slope down to the left, they must eventually curve up to the top again as n approaches infinity, for if one takes increasingly large samples even from rather a poor mixture one will eventually obtain the whole mixture in the sample, and the sample composition *must* therefore be right. The curve obviously must cease at the point where n is the total number of particles in the mixture; on this scale that point is indistinguishable from infinity. The dotted lines above the ideal mixture represent the super-mixtures which might be obtained by a rare chance. It will be observed that the curves in such a diagram are actually discontinuous and consist of series of points, since n must always be an integer.

(*To be continued.*)

FUEL ECONOMY NOTE

In a chemical works a boiler of the stationary loco. type was found to be very hard pressed and, although a chimney of considerable size was available, steam injection was necessary to maintain the draught. It was found that vapours from open-top boiling tanks were being discharged into the chimney by means which completely spoiled the draught. When the pans had been hooded and the vapours disposed of separately, the steam blower was found to be no longer necessary.

Among other improvements, the design of evaporator coils was altered to give complete drainage, together with correct steam trapping and air venting. The condensate from these coils was returned to the boiler. The injector feed was replaced by a pump from a new elevated feed tank. The steam distribution system was properly lagged. The brickwork of the calcining furnaces was repaired. The first result was a saving of 20 per cent. in the fuel consumption. The second, which may ultimately be of greater importance, is that this firm has asked the Regional Fuel Efficiency Committee for advice on their post-war plans for a new plant lay-out. (*Fuel Efficiency News*, No. 27.)

FUEL EFFICIENCY IN THE CHEMICAL INDUSTRY

Fuel Economy Discussions

V.—The Simultaneous Generation of Power and Process Steam

by OLIVER LYLE

IT is almost impossible for a plant to be so bad that it is not in the national interest, from the purely coal consumption point of view, to combine power and process. The correct costing of back pressure power is widely misunderstood. The only heat cost is the conversion of heat into power and the true losses that are incurred in the process.

Types of Heat Loss

The losses that take place in a power-generating machine must be examined in some detail, carrying out some mopping-up operations *en route*.

1.	Radiation	(common).
2.	Leaks to atmosphere	
3.	Friction and windage	
4.	Generator loss	
5.	Wire-drawing	
6.	Cylinder condensation	(engine).
7.	Valve leakage	
8.	Piston leakage	
9.	Tip and interstage leakage	(turbines).
10.	Blade friction	
11.	Gland leakage	
12.	Exhaust loss	(common).

(1) *Radiation.*—This is an unpreventable loss, but it is one that we can do much to minimise. When walking round someone else's works we look down our noses at unlagged pipe flanges, but once in the engine room we gaze in admiration at the bare cylinder flanges, the naked cylinder covers, and the strip-tease valve chest. Of all heat-losing surfaces the cylinders of engines deserve a maximum of lagging and receive a minimum. Turbines are little better served. A thin layer of plastic composition is slobbed on to the casing. The massive flanges and their multitude of bolts are often left bare. This iniquity is then concealed by a beautiful planished cover.

(2) *Leaks to Atmosphere.*—These are to some small extent inevitable, but occur too often and too largely. In a hot engine room leaks are usually invisible; they are certainly invisible if the steam is superheated. Let us remember always the wickedness of leaks. A hole 1/16 in. dia. or its annular equivalent, at 1 in. gland with about 5/1000 in. clearance, loses 14 tons of coal a year on three shifts at 300 lb./sq. in.

(3) *Friction and Windage.*—There is little we can do about these. They are matters for the machine builder.

(4) *Generator Loss.*—Here all we can do is to improve the power factor, though power factor improvement of itself is one of the least paying of investments except in one special case. Suppose, for example, we have a small plant with two sets of 175 kW capacity. Quite normal back-pressure conditions will be such that each engine uses 3000 lb./hr. of steam on no load, and 7000 lb./hr. on full load. If the power factor is such that one set is overheating at 150 kW when it is using 43 lb/kWh, it will be necessary to start the second set to get the extra 25 kW that a fully loaded single set should give. At 25 kW the second set will incur all the losses associated with one machine and will use 140 lb./kWh. If such conditions exist, and there is no good use for the extra exhaust steam, power factor improvement may be very fruitful.

The above four losses are external losses. They are irrecoverable, but with care they can be reduced.

(5) *Wire-Drawing* is an internal loss. No heat is lost by wire-drawing; there is a degradation of energy. Good heat which might have generated power is depraved and loses its virtue. If the engine is throttle-governed the wire-drawing can sometimes be materially reduced by altering the cut-off.

Engine and Turbine Losses

The five losses so far mentioned are common to all machines. Let us now look at those losses which are peculiar to engines and peculiar to turbines, first noting slight differences in the common losses. There is a small extra radiation loss in an engine due to the piston rod coming out of the hot cylinder at every stroke for a breather. There is nothing we can do about it. With turbines there is generally a rather larger leak to atmosphere from a turbine gland than from a reciprocator gland, and turbine gland leakage can easily be allowed to get out of hand.

(6) *Cylinder Condensation* has three causes. One is the making good of the heat lost by radiation, which has already been dealt with. The second is due to the conversion of heat energy into power energy which is what we want to be happening.

The third is the most important. During admission the ingoing hot steam heats the valve ports, steam passages and cylinder walls, and it loses good heat and causes condensation. During exhaust at lower pressure most of the heat put into the metal is given back to re-evaporate part of the condensate. This heat is lost to power generation but it goes out in the exhaust and is available for heating.

(7) *Valve Leakage*; (8) *Piston Leakage*; (9) *Tip and Interstage Leakage*; (10) *Blade Friction*. All these losses are losses to power generation only. All the heat in the steam that sneaks through these leaks goes out, with any blade friction heat, in the exhaust, and is available for process.

(11) *Gland Leakage*.—Most turbine glands are in two or more main stages. Many turbine makers specify that the gland leak should be piped to atmosphere. The only benefits this carries are that it lowers the pressure on the last stage of the gland and gives visible and audible notice of the leak. Gland leaks are often very severe, especially if the gland has been damaged by too quick a run up. In my factory the turbine glands are damaged and the H.P. gland is leaking about 4000 lb./hr. and the L.P. gland about 3000 lb./hr. These glands go to the process main, so that although 4000 lb./hr. of steam is lost to power generation none of it is lost to process. The extra back pressure put on to the gland by piping the steam to process will slightly increase the final gland leak to atmosphere.

An Inevitable Loss

(12) *Exhaust Loss*.—This is a power loss common to all types of machine. It embraces many of the losses that have already been considered by its major constituent as the inevitable loss from a heat engine working on a vapour cycle. The exhaust loss is by far the greatest single loss. In a high-grade condensing power station the exhaust loss represents about 65 per cent. of the heat put into the steam in the boiler. In an engine exhausting to atmosphere, such as a locomotive or a colliery winding engine, the heat lost in the exhaust may be about 85 per cent. or 90 per cent. of the heat put into the steam. Most of this loss is cycle loss; it is inevitable. The cycle loss in a big power station is about 55 per cent. and of a locomotive about 75 per cent.

Now this cycle loss disappears if we modify the cycle so as to use the heat in the exhaust steam. A combination of power generation with exhaust heating starts off with a cycle efficiency of 100 per cent. By combining power generation with heating by exhaust steam we not only capture the cycle loss but we secure six of the losses that we have just considered, namely, Nos. 5, 6, 7, 8, 9 and 10, all of which are dead losses to the pure power generator.

TABLE 1
ENERGY DISTRIBUTION

	Good Power Station	Good Heating Plant	Bad Heating Plant	Combined Heating & Power Plant Good	Combined Heating & Power Plant Bad
Heat in ...	100	100	100	111	106
Boiler loss	15	17	50	19	53
Generator loss	1	—	—	1	1
Auxiliaries	1	1	2	1	2
Exhaust ...	54	—	—	—	—
Condensate	—	—	6	—	6
Process heat	—	82	42	82	42
Power ...	29	—	—	8	2
Coal : lb./kWh.	.99	—	—	.39	.83
Cycle Efficiency	45%	100%	100%	100%	100%
Generating efficiency	29%	82%	42%	73%	33%
Overall efficiency				81%	41%

First Column.—In a good power station, out of 100 heat units liberated in the boiler furnace 15 are lost in the boiler plant, 1 is used by the auxiliaries, 1 is lost in the turbo-generator, 54 pass out of the exhaust and 29 are converted into power. The cycle efficiency is about 45 per cent.; the actual efficiency is 29 per cent.; the coal used is just under 1 lb./kWh.

Second Column.—This shows a good plant raising steam for process use only. We have weighted the scales against the plant by taking the same auxiliary debit as in the power station, although the feed pump will use much less power, and we have assumed a 2 per cent. boiler efficiency. The cycle efficiency is 100 per cent. and we achieve 82 per cent.

Third column.—Here is a bad plant raising steam for process only. It shows a boiler efficiency of 50 per cent., a deplorable feed pump exhausting to atmosphere, and a loss of 6 per cent. which represents lost heat in the condensate. In spite of all these handicaps the plant achieves an efficiency of 42 per cent.

Now let us take these two heating plants and raise steam at a higher pressure with a little superheat. We will again weigh the scales against the factories. We will assume that the boiler-house losses will be even greater.

Fourth and Fifth Columns.—In both factories we pass the same amount of heat as before to the process, but from the extra heat we generate some power. The heat that goes to process has nothing whatever to do with the power generation so we can ignore it. We are concerned only with the extra heat that was put into the steam and the power that this enabled us to generate. In the case of the good factory by putting in an extra 11 heat units 8 were converted into power, and efficiency of power generation is 73 per cent. In the bad factory an extra 6 units put into the steam produced 2 power units, an efficiency of 33 per cent. This is an extreme case. It assumes that the losses in the engine and generator equal 50 per cent. of the power output. As all the power-producing losses are external

they must all go into the engine room which would be almost uninhabitable. But such engine rooms do exist in those factories which carry out the triple function of power, process, and Turkish bath.

Now this horrid little factory produces electricity or mechanical power with a greater efficiency, from a coal-consumption point of view, than does the finest condensing power station in the land. Its over-all efficiency is 42 of process steam plus 2 of power from 106 of input heat, or 41 per cent. The over-all efficiency of the good combined plant is 82 of process steam plus 8 of power from 111 of input heat, or 81 per cent.

How can we find out just how great a heat loss we must debit to power generation? We can calculate the adiabatic heat-drop, but adiabatic heat drop has nothing whatever to do with the question. There is a mass of data as to efficiency ratio, but the efficiency ratio is the measure of all the losses to power generation and we have seen that we recover many of these losses for use in the process, so that we must ignore them. We want to know the amount of the true losses, *viz.*: (a) radiation; (b) leaks to atmosphere; (c) windage and friction; (d) generator losses.

True Heat Drop

If we know or can measure the heat content of the steam at the machine stop valve and at the exhaust, the difference is the true heat drop over the machine. If we multiply this by the weight of steam passed through the machine we have the total energy used in power generation. Comparing this with the heat equivalent of the power generated, we get the true generating efficiency. But until we know the true heat drop over the machine we can draw no inference whatever from the steam consumption, nor can the adiabatic heat drop give us any help at all. Let us take an absurd example.

Take an engine running on three-quarter load and generating power with a steam consumption of 30 lb./kWh. Let us now increase the steam consumption to 40 lb/kWh in two ways. First, by removing the cylinder lagging and spraying the cylinder with cold water. Secondly, by drilling a hole in the piston. In both cases the governor will open full while the load remains the same. In the first case all the latent heat in the extra steam is being lost and the real heat consumption of the engine will have been trebled. In the second case there is no increased heat loss at all. The steam that goes through the hole in the piston goes straight to process, but the engineer who bases his power costs on adiabatic heat drop and steam consumption will treat both in the same way and will wring his hands and say his power heat costs have gone up by 30 per cent. In both cases he is wrong. In the first case his heat costs have gone up by 200 per cent. and in the second case by nothing at all. *Provided the whole of the exhaust steam is usefully employed it does not matter how much the piston leaks or how many blades are missing from the turbine.* The only effect of such things is that from a given amount of steam a smaller amount of power will be available. Steam consumption gives no clue as to heat consumption.

Exhaust Calorimetry

How can we find out how much heat to debit to the machine? Only by measuring the heat in the exhaust steam. If the exhaust steam is superheated, a thermometer and a pressure gauge will give the answer straight away. If the exhaust is wet, the answer is difficult to produce and may not be reliable. The calorimetry of wet steam, with a bucket calorimeter, is fairly easy, but who can say whether the steam drawn from the pipe is a true representative sample?

Here is an example of the easy superheated case taken from the turbine in my factory one night a few months ago on light load:—

Steam flow	71,500 lb./hr.
Initial total heat	1325 B.Th.U./lb.
Exhaust total heat	1202 B.Th.U./lb.
Electrical output	2250 kW.

$$\text{Heat used} = \frac{71{,}500 \times (1325 - 1202)}{2250}$$

$= 3090$ B.Th.U./kWh or 87.4 efficiency.

Boiler efficiency 81 per cent. Over-all generating efficiency 71 per cent.

The adiabatic heat drop for these conditions is 195 B.Th.U. Had this figure been taken the power generation would have been debited with 6158 B.Th.U./kWh, or 58 per cent. too much, and the over-all efficiency would have seemed to be 45 per cent.

In the absence of a fairly reliable exhaust calorimetry we must have some empirical factors. It will be one of the purposes of this discussion to arrive at suitable empirical figures. Of course, we must never forget that in all the calculation and argument there is one over-ruling proviso. The *whole* of the exhaust steam must be usefully employed.

Can we give a more reasoned answer to the question whether power should be bought or generated? If the power set is small and electricity can be bought cheaply it may pay financially to buy power. From the national coal conservation point of view it is almost impossible to have such a bad engine that power cannot be generated for less heat than by the finest power station, provided all the exhaust steam can be economically used. At present prices a large plant can generate back-pressure power for under ¼d., a moderate-sized plant for between ½d. and ¾d., and a very small

plant for about ¾d. to 1d. The big back-pressure plant can generate power for the consumption of about ⅜ lb. of coal per unit and the very small bad plant will burn about ⅞ lb.

Pass-out power is more difficult to cost. The pass-out steam should be calorimetered as well as metered for quantity. Then the heat to be debited to power is the total steam heat put in less the heat passed out. If pass-out calorimetry is too unreliable the pass-out heat loss must be "guesstimated" by using a factor on which I hope we shall agree.

TABLE 2
(communicated by Mr. Lyle after the discussion)
APPROXIMATE BACK-PRESSURE POWER STEAM HEAT CONSUMPTION

Size of Set kW	B.Th.U. taken from Steam per kWh.
Over 3000	3415 × 1.1
1000 to 3000	3415 × 1.125
250 to 1000	3415 × 1.15
100 to 250	3415 × 1.175
50 to 100	3415 × 1.2
Less than 50	3415 × 1.25

Discussion

Q.—Will the C.E.B. allow a factory to connect with the Grid to pass surplus current to the Grid or draw from the Grid?

A.—There are some factories working in this way, but many electricity supply companies seem to raise objections of one sort or another.

Q.—Is it always an economic proposition to supply the Grid with power from a back-pressure set?

A.—It might not pay very much to instal a back-pressure plant simply in order to sell to the Grid, but it would surely pay to use peak capacity and sell the peaks to the Grid, at, say, ¼d. a unit.

Q.—Is the price structure of electricity supply such that advantage can always be taken of the cheap production of electricity in a back-pressure set? My firm put in a new back-pressure set and approached the electricity supply company for standby quotation and were offered the supply at an annual figure equal to the amount of power we generated, which is ridiculous; but the power company will not alter their attitude.

A.—All sorts of rates are quoted, some of which show a very marked benefit by back-pressure generation, others show little or no benefit.

Q.—The whole crux of the matter is that the big stations have to condense. Is district heating the answer?

A.—There is no doubt that theoretically the distribution of heat is a very attractive proposition, but except in a few cases it is doubtful whether anyone would face the capital cost. Suppose Manchester suddenly decided to adopt district heating for the whole city, trenches would have to be dug along every street, and every factory and every house would have to have a connection put into it. Manchester would surely decide that it had not sufficient money for this purpose. The only way district heating could become practical is the way in which electricity distribution and gas distribution came; it would have to be gradual or applied in a brand new town or to part of a town that was being completely rebuilt.

Q.—In costing back-pressure electricity what charges should be allocated?

A.—The heat equivalent converted to steam should be charged and any increased costs incurred by generation, such as the increased capital value of the boiler plant due to higher pressure, the capital cost of the engine, the attendant's wages, etc.

Q.—Should not steam be costed by the therm instead of per unit weight?

A.—Certainly it should be costed on some standard basis either "from and at" or per therm. The therm is not necessarily the best unit.

Q.—We need not associate the therm only with gas. Do we not get the real picture by taking the cost of 1000 lb. of steam "from and at"?

A.—1000 lb. of steam "from and at" is 9.7 therms.

Q.—Is not the right way of costing back-pressure power to ignore all boiler-house overheads and only charge to power its proportion of coal? The boiler plant will be required anyhow.

A.—This is only true up to a point. If a back-pressure set is added to an existing installation of boilers then no boiler-house charges, other than the true coal equivalent, need be debited to power. However, in most installations the boiler has a higher pressure than it would otherwise have and power should bear a little of the other boiler-house charges. It can be argued that if you are putting heat into a factory, every B.Th.U. for whatever purpose it is used, should bear its fair share of overheads and other boiler-house costs. I rather sympathise with you, but I am not sure that you are right.

Q 1.—I agree with the previous speaker. Where the power is a by-product should it not only be charged with the direct cost?

Q 2.—I come down on the same side as the last speaker. Can this costing be done with an accuracy that gives reasonable accounting?

A.—There are surely some charges that must be debited to power generation even if you want all the steam for process. For example: steam raised purely for process at low pressure may not call for such elaborate water-softening as that required in a H.P. boiler. The extra cost of the more high-faluting softener should surely be debited to power.

Q.—In the absence of a knowledge of the real heat drop what is an estimate of the losses in a back-pressure machine?

A.—This is one of the things we want to get at in this discussion. In one turbine of about 2500 kW the heat consumption is about 1.12 times the theoretical (Table 2).

(Suggestions by those present were that a 10 per cent. loss on 750 kW is about right; the losses on a 100 kW set were estimated to be about 17 per cent. and on a 300 kW set about 15 to 20 per cent.)

Q.—Is not a complete survey of steam-using equipment and power plant essential before deciding on the installation of the back-pressure set?

A.—Such a survey is most desirable because economies can often be made to such an extent as to render the back-pressure set incapable of generating the requisite power.

Q.—Should some superheat be present in the exhaust to process?

A.—Yes, it is desirable first to reduce the heat loss in distribution, and secondly to ensure that the steam arrives dry at the process plant.

Q.—Is the cost of low-pressure distribution justified?

A Member: High-pressure distribution means many reducing valves. Back-pressure sets replace reducing valves and call for low-pressure mains. We find that low-pressure distribution has saved a great amount of maintenance on reducing valves.

A.—Low-pressure distribution undoubtedly costs more, particularly its lagging, but there would seem to be a slightly smaller heat loss from a low-pressure main than from the same amount of heat transmitted through a high-pressure main.

Fluctuating Loads

Q.—At what point do fluctuations make power generation impracticable?

A.—It all depends on whether the fluctuations are short-term or long-term and how big they are. If the power demand is fairly constant and the heat demand is widely varied over several hours, the problem is simply one of the cost of generating by exhausting to atmosphere. In a number of back-pressure installations it pays well to exhaust for short periods, say, 20 to 30 per cent. of the time, to atmosphere. Another solution is to sectionalise the factory with two sets of bus-bars, one of which takes current from the Grid, and switch over during the valley periods. If the peaks are matters of minutes the exhaust accumulator is probably the solution.

Q.—What benefits can be derived from steam accumulators?

A.—It often seems difficult to justify an accumulator before buying it, but it also seems that anyone who has one installed would be very unwilling to part with it. It is often much more beneficial to store exhaust steam from the back-pressure machine than to store high-pressure steam, because the high-pressure steam cannot be used for generating power as it has to be discharged at a lower pressure.

Q.—Is the gas-holder type of accumulator in practical use?

A.—Yes. There are at least three working in collieries, in conjunction with winding-engine exhausts and mixed-pressure turbines. One of these has been going up and down 40 times an hour for 31 years.

Q.—Have you considered the reasonable limits of steam and power balance? What sort of limits would be considered practical?

A.—It really depends on the particular local conditions and especially on what you have to pay for electricity supply.

Q.—Should we not generate at much higher voltages and so cut out many of the losses associated with low voltages?

A.—I understand it is only economic to use high voltages with motors of not less than 50 or 100 h.p., and I believe I am right in saying that the average motor throughout the country is about 10 h.p.

Q.—In small units the turbine steam consumption will be great, an ordinary reciprocating steam engine will be better, and the Uniflow better still. Which should be adopted?

A.—The turbine will almost certainly have lower maintenance costs, and provided it will generate enough power it should be the first choice. Although the turbine is extravagant in steam it is not at all extravagant in heat; the heat all goes down the exhaust pipe. Although a reciprocating engine takes less steam and therefore gives more power it certainly uses rather more heat. I always feel that the Uniflow has been sadly neglected.

H.P. and L.P. Steam

Q.—Is it sometimes better to use the steam from the boilers for evaporators and the exhaust from the evaporators for power generation?

A.—This point is exceedingly interesting. Far more power can be produced from low-pressure steam down to high vacuum than from high-pressure steam down to process pressure. The evaporator does not usually mind what sort of steam it uses. The real trouble is that such a power plant working between, say, 10 lb./sq. in. and 28 in. of vacuum is far more costly than working between 200 lb./sq. in. and 10 lb./sq. in., although the power produced in the former case would be greater than in the latter.

A plant had been investigated which would take vapour from a 60-ton vacuum pan averaging about 30,000 lb./hr., discharging at 24 in. of vacuum into a turbine exhausting into a condenser at 29 in. It was estimated that 500 kW could be obtained, but the capital cost came to £42/kW but, of course, in this case the power would have been obtained absolutely free from a coal point of view.

New High-Speed Agitator

Suitable Equipment for Pressure Vessels

WRITING from the Coal Research Laboratory, Carnegie Institute of Technology, Pittsburgh, Pa., M. W. Kiebler (*Ind. Eng. Chem.*, 1945, *37*, 538) describes a totally-enclosed motor and agitator, built to operate under extremely severe conditions of pressure, temperature, and chemical attack. The stirrer assembly (Fig. 1) is constructed as an integral unit which is attached to the bomb head by means of the threaded lower end. The autoclave was built in the laboratory several years ago to study the hydrogenation of coal in aqueous alkali at temperatures and pressures up to 400° C. and 6000 lb./sq. in. Violent agitation is required in this reaction to produce not only the maximum possible gas-liquid interface, but to prevent the coal particles from fusing together. Sufficient turbulence was obtained in this autoclave by rotating a 2-in. nickel propeller at 1500 r.p.m. in a 750-c.c. nickel-lined cylindrical bomb of 3-in. internal diameter.

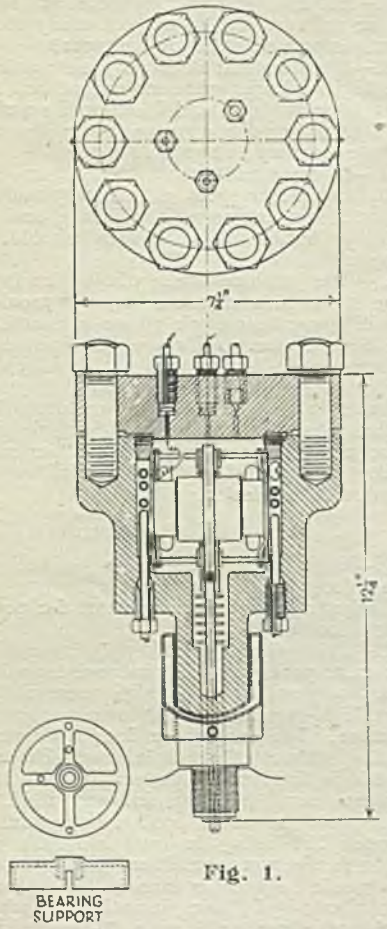

Fig. 1.

Special Alloys Used

The body and top closure for the assembly were machined from chrome-vanadium steel forgings which were heat-treated and drawn at 480° C. in a salt bath after all machine work had been finished. Data available for this alloy indicate that the resulting product should have a tensile strength of 210,000 lb./sq. in., and a Brinell hardness of 470 (48 Rockwell C). The studs were made of a chrome-nickel steel drawn at slightly lower temperatures to give a tensile strength of about 200,000 lb./sq. in. The nuts, made of the same alloy except for a lower carbon content, were carburised for surface hardness. To reduce contamination of the bomb contents, the interior of the assembly was given a thick coat of silver and burnished. The top closure was made up against an unconfined copper gasket which had an internal diameter of 4 in. Silver gaskets were used between the assembly and the head and between the head and the reactor body. A tight-fitting copper condenser on the neck of the assembly served to remove the heat which flowed up from the heated reactor. Six nickel discs were attached to the nickel stirrer shaft to create turbulence and expedite heat removal.

All parts of the electrical system had to be resistant to attack from hydrogen, water, and organic vapours. A shaded-pole 1/30-horsepower motor was obtained, and the outer cover removed. Two bearing supports (Fig. 1) were made for the top and bottom of the motor. An Oilite bearing was pressed into each support to take the rotor shaft. It was planned to replace these bearings with graphite bushings if hydrogen or organic vapours should remove the lubricant, but this has never been necessary. The supports were held tightly against the stator ends by two bent bolts which passed through slots at opposite sides of the stator. These bolts were salvaged from the motor parts.

Stators and Desiccator

Two stators have given satisfactory service in this apparatus. The first was taken as it came from the manufacturer and was given about six coats of a bakelite varnish. The second was made by winding Formex wire on to a Redmond stator frame and alternately coating the coils with Heresite varnish (No. L-100) and General Electric varnish No. 1676. Each stator was impregnated by suspending it in a container of varnish which could be placed in a vacuum

desiccator. The pressure in the desiccator was then alternately decreased and allowed to return to atmospheric to remove entrapped air. The stator was then drained, air-dried, and finally baked. After each of several impregnations, the stator was supported in a different position for drying and baking. Any varnish which adhered to the outside diameter of the stator was removed with sandpaper. The assembled motor was tested by allowing it to run under water.

Because this motor has no starter brushes or windings, only one lead has to be taken out through the reactor wall with the other lead internally grounded. However, in this design both leads were brought out so that the motor insulation could be more accurately checked. The leads were made by brazing a copper disk on a short piece of heavy nichrome wire and slipping a bakelite disk over the wire on each side. The three disks were then crushed together under a gland nut in the top closure. Both the diameter and thickness of the bakelite must not be less than that of the copper disk. Nichrome wire was used in preference to copper because of greater strength and stiffness. The resistance to ground through this type of seal has always been more than 500,000 ohms.

A coil which serves to remove heat from the motor stator was made by bending a piece of $\frac{1}{4}$ by $\frac{3}{8}$ in. mild steel tubing to form a long narrow U, which was then wound into a helix. The two ends were separated 180° apart, bent at right angles to the helix, and dropped through holes at the bottom of the motor compartment where they were made up against the wall with compression cones. The only change contemplated for this autoclave is to increase the internal diameter of tubing used in the coil.

Final Assembly

The final assembly was made by attaching the stirrer shaft to the motor by means of a bushing, and then pushing the shaft and motor through the coil so that the motor rested against a shoulder near the lower part of the compartment. A ring which served to centre the motor and hold it firmly against the shoulder was then pressed against the top bearing support, and a low-melting alloy (20 lead-40 tin-40 bismuth, melting at 945° C.) was poured through a hole in the ring. This ring, which has two set screws to hold it in place, was removed after the alloy had solidified to facilitate making up the electric connections. The alloy provides good heat transfer between the coil and stator. The motor can be removed by turning the assembly upside down and passing superheated steam through the coil to melt the alloy. The gasket was put in place, several studs were removed, and the top closure was held a short distance above the assembly so that the motor leads could be soldered to the nichrome wires. After all exposed wires were carefully insulated and coated with thickened varnish, the final closure was made.

The solid nickel head to which the assembly was attached was fitted with a thermocouple well, a safety disk, a gas inlet, and an outlet which could be used in conjunction with a siphon tube to charge and empty the bomb without removing the head. The nickel fitting on the lower side of the head held a graphite bushing to take the stirrer shaft. At various times this fitting has been replaced with a simple packing gland, in which case the pressure in the assembly and bomb were equalised by a connecting tube. The assembly and head, which weighed about 80 lb., could be conveniently raised above the stationary nickel-lined bomb by a cable and by one fixed and one movable pulley.

Gas Research Extension

New G.L. & C. Appointments

THE directors of the Gas Light & Coke Company have considered the further development of the research work which the company has carried out in a wide field for many years, and they have decided to broaden the basis of the programme and to arrange for improved co-ordination of effort within the company. Dr. H. Hollings, hitherto the chief gas chemist of the company, has been appointed controller of research and he now becomes responsible for the activities of Watson House as well as those of the Fulham research laboratory.

As part of the new arrangement the directors have made the following further appointments: Mr. W. Dieterichs to be manager of Watson House; Dr. G. C. Halliday to be manager, Gas Light Centre; Dr. R. H. Griffith to be senior research chemist; Dr. S. Pexton to be senior chemical engineer.

COBALT DEFICIENCY

The use of cobalt as a top dressing to cobalt-deficient pasture had made such tracts of land at least temporarily adequate in cobalt, said Dr. Russell Greig at the annual meeting of the Moredun Institute of Animal Research. A survey made in co-operation with the Macaulay Institute for Soil Research had shown that much more extensive areas than were thought were deficient in this most important trace element and that spectacular results had followed the application of cobalt in such areas. Evidence now available suggested that the pining of earth in the Solway area was essentially due to a deficiency of cobalt and work was continuing to determine this point finally this year.

Progress in the Provinces

Reports from a Chemical Engineering Correspondent

YORKSHIRE

DURING the last twelve months it has been found possible to consider plans for the future with the object of adopting methods that will facilitate the fulfilment of demands likely to be made during the early post-war period. Plans for the installation of the most modern types of chemical plant and equipment are now well advanced, and some firms have placed orders for entirely new lay-outs. The industry in this area is well aware of the necessity of producing by the most up-to-date methods and at the lowest possible price, and is fully alive to the fact that future prosperity depends to a large extent on ability to compete in the markets of the world; consequently, everything possible is being done to lower costs.

Firms whose function it is to supply other industries with essential materials—and there are very few industries or trades which do not use a material or a process developed by the chemical industry—are doing much to improve their products, and it is doubtful whether the proportion of trained scientists to total workers is as high in any other industry. In the field of organic chemicals many problems come up for solution by experts in every branch of science, and recent triumphs of research which present great possibilities for the immediate future are the announcement of a new insecticide, and the discovery of a revolutionary weed-killer. The former, which is already in small-scale production, is cheap and easy to manufacture, less injurious to other forms of life, and is regarded as a most effective controller of insect pests, and the weed-killer is being subjected to trials in co-operation with the Ministry of Agriculture, and promises to prove an effective agent in the destruction of weeds that infest cornland.

Enamelling is one of the most important and one of the most widely used finishing processes in the North where cars, typewriters, and thousands of other commodities require enamelling. Having regard to modern continuous production methods of manufacture, it is advisable that enamelling processes should be brought into line to guarantee that the finishing department does not put a brake on post-war speeds. An interesting example of high-speed enamelling is to be seen at the works of a company which manufactures something like half a million cycles a year, and utilises every available method. In this case, fine enamelling is of the utmost importance and great care is taken over the process. Seven gas-fired conveyor ovens are used, and are divided into two groups for enamelling cycle frames in black and various colours. The standard black-finished frames are stoved in ovens measuring 56 ft. long by 9 ft. 6 in. wide by 5 ft. high inside, and the larger parts, including front forks, frames and backstays, undergo a three-coat process. The parts first go to the dipping room where they are dipped in the enamel of the required colour, and on emerging (still attached to the conveyor) they are carried through a drying tunnel which is maintained at a uniform heat which never varies more than 5° C., so that accurate control over the viscosity and specific gravity of the enamel is preserved. Parts detailed for colour finishes are dealt with in a similar oven, the interior measurements of which are 25 ft. by 12 ft. by 9 ft., and in which the parts make four journeys up and down the oven chamber on the conveyor. The average capacity of the enamelling plant is 10,000 complete cycles per week, while, in addition to the larger parts, up to 650,000 small parts are dealt with every week. It is claimed that the use of gas-fired conveyor ovens has the advantage that as gas is a clean fuel a direct fire or heater can be used where in most cases an indirect type would have to be employed. Also, the need for the regular replacement of air heater elements, which are made of expensive material, is avoided.

Methods of drying products such as confectionery by the use of moist air have been greatly improved, and before entering the drying room all the air, whether recirculated or fresh from outside, is now passed through a water-spray chamber to receive its correct proportion of moisture to suit the goods. The moisture held in suspension in the air circulated through the goods enables the drying to be carried out in much higher temperatures without the risk of burning or skinning, and also allows of drying from the centre outwards.

LANCASHIRE

The condition of the chemical industry in Lancashire is very fluid, yet some firms do not appear to possess sufficient liquid resources to make good the depletion of capital. It seems probable that the unusual liquid position of industry as a whole is due to an exceptional accumulation of resources arising from conditions which will disappear as soon as the present economy ceases to operate. Many manufacturers are quite unable to utilise their resources for normal maintenance and replacement, and at the same time the excess of consumer demand over supply means that to a large extent cash settlements are replacing normal credit transactions. . On the other hand, the frequent changes in design cause some stocks

and work in progress to become redundant, and in the near future many firms will be needing extra funds to enable the arrears of capital expenditure to be met and ordinary credit terms to be granted to customers. When it is no longer possible to utilise Government-financed capital assets and stocks, the serious drain on liquid resources will undoubtedly call for extended bank overdrafts and many private loans. Collaboration should have as its main objects the avoidance of duplication of capital and revenue expenditure in the expansion of peace production, and the pooling and speeding-up of highly specialised industrial research. Some executives maintain that a rationalisation of orders would permit longer and more continuous runs of the same types, and that it would eliminate unnecessary duplication of process lay-outs, with a material reduction in production costs and speeding-up of delivery dates.

Water Softening

An interesting method of softening boiler feed water by trisodium phosphate claims to secure total immunity from incrustation and freedom from the possibility of corrosion. It is stated to be much more economical than the direct softening of raw water by trisodium phosphate. The feed is first preheated in a cascade heater by means of waste steam (even oily exhaust can be used) and followed, if necessary, by live steam. The second stage is the treatment of the raw hot water by alkaline water returned from the boiler on the lines of a continuous blowdown system, but by direct contact. Trisodium phosphate is added in the third stage and results in the precipitation of all remaining hardening constituents. It is used as a 10 per cent. solution, the softening being completed to practically zero hardness so that it is not possible for sludge or scale to form. The final precipitation forms sodium carbonate which passes into the boiler, where it is partly converted into caustic soda. Where space is limited, tubular equipment appears to meet the conditions effectively, while the standard outfit is a compact unit with low maintenance. The consumption of trisodium phosphate is about 2 oz. per degree of total hardness per 100 gallons of water, and if calcined trisodium phosphate is used the consumption is about half this amount. A simple form of testing apparatus is used to ascertain the very slight excess of phosphate in the boiler water, and such tests can be readily made by a charge hand.

In Switzerland, polyvinyl chloride is being used on a fairly large scale for the manufacture of shoes, and various ladies' and children's wear made from transparent and coloured sheeting from the same base, the *Oil and Colour Trades Journal* reports.

Pulverising Coal by Steam

An Interesting Process

PRODUCTION of finely pulverised coal by a process similar to that employed in making "Puffed Wheat" has been shown to be practical. Coal is shot from guns, in which it had been subjected to steam at high temperature. When the pressure in the gun is suddenly released, the pressure within the coal pores explodes it into small particles.

Early experiments were made with a sealed tube filled with coal and water, and designed to rupture at one end when heated externally to a pre-assigned pressure. Results were so promising that a new tube was built with a hydraulically-operated quick-opening valve, and furnished with high-pressure steam under controlled conditions, which made it possible to study the effect of steam pressure, time of soaking, and quickness of release, on the yield obtained. Discharge of coal against a target increased pulverisation.

By subjecting the products of one expansion to another expansion, the same yield ratio of fines was obtained, and the ratio maintained in successive explosions. This feature of the process makes possible the introduction of classifiers and separators to control the size of the final output.

In one of the tests made, 5/16 in. by 6-mesh coal was exploded by steam at 900 lb. pressure, air classified, and size-separated for re-cycling three times, and gave a final cleaned product having the following screen analysis:

On 60-mesh	0.1 per cent
On 60 by 100-mesh	5.4 per cent
On 100 by 200-mesh	28.9 per cent
Through 200-mesh	65.6 per cent

Finer pulverisation could have been obtained by additional cycles.

Coals vary widely in their porosity, and further experiments on coals from other fields remain to be carried out. Large-scale tests must also be made to establish the comparative costs of this system with that of mechanical methods. For a commercial application, the steam consumption is calculated to range between 106 and 151 lb. per ton of coal pulverised.

A slow release of the steam pressure caused the coal to expand permanently into a highly porous structure. When the coal was heated to the plastic range in an atmosphere of steam, a caked mass resembling semi-coke resulted. Further, in view of the fact that impurities such as bone and pyrites are less porous than the coal substance, the possibility of reducing the ash content of the coal in the new method of pulverisation may be another incentive to the development of the process.

Personal Notes

MR. W. I. ALISON has been appointed a director of Barry, Ostlere and Shepherd, Ltd., linoleum manufacturers, Kirkcaldy.

MR. CLEMENT DAVIES, K.C., M.P. for Montgomery, has been elected chairman of the Liberal Parliamentary Party. He is a director of Lever & Unilever.

DR. M. SOLLER and MR. J. H. SPILMAN, who have been on the board of British Celanese since 1927, have now been appointed additional managing directors of the company.

SIR J. BOYD ORR, Professor of Agriculture at Aberdeen University, and a leading expert on nutrition, has been re-elected as Independent Member for the Scottish Universities

DR. H. J. GOUGH, chief scientific officer to the Ministry of Supply, has been released from his post. His successor is PROFESSOR J. E. LENNARD-JONES, F.R.S., who was chief superintendent of the Armaments Research Department, M.O.S., since 1942.

MR. GEORGE WESLEY AUSTIN, M.Sc. (Birmingham), has been elected into the Goldsmiths' Professorship of Metallurgy in the University of Cambridge from October 1 next, in succession to Professor R. S. Hutton, who has retired.

DR. N. G. BAPTIST, chief technical officer in the Ceylon salt department, has been awarded a fellowship under the Colonial Development Fund, for research in Ceylon vegetable proteins. He is the first Ceylon scientist to be awarded such a fellowship.

MAJ.-GEN. H. W. GRIMWADE, C.B., C.M.G., has been appointed chairman of Felton, Grimwade and Duerdins Pty., Ltd., Melbourne, Australia, in succession to his brother, the late Mr. E. N. Grimwade. The company is associated with The Drug Houses of Australia, Ltd

MR. J. R. DONALD, director-general of the chemicals and explosives branch of the Canadian Department of Munitions and Supply since 1939, has resigned, and will leave shortly for the United Kingdom and Europe on a special mission. Upon his return, he will go back to private business as a consulting chemical engineer with J. T. Donald & Co., Ltd., of which he is president.

The Trustees of the Nuffield Foundation are making a grant of £1045 a year for five years for a special research fellowship for DR E. OROWAN, of Gonville and Caius College, Cambridge, to enable him to continue his work in the Cavendish Laboratory on the plastic properties of metal, and, in addition, to provide £455 a year for the same period as a contribution towards the cost of the fundamental research work undertaken by him

DR. W. V. EVANS, formerly head of the chemistry department of Northwestern University, U.S.A., has been appointed chief of the chemistry department of the U.S. Army University Study Centres at Shrivenham (Wilts.) and Fontainebleau, near Paris. He will be accompanied by a staff of eleven.

VISCOUNT STANSGATE, D.S.O., D.F.C., whose appointment as Secretary for Air in the new Government was announced last Saturday, was in his early years an active member of the family firm of Benn Brothers, Ltd., proprietors of THE CHEMICAL AGE. He is the second son of the late Sir John Williams Benn, the founder of the business, and brother of Sir Ernest J. P. Benn. First elected to Parliament in 1906, Mr. Wedgwood Benn, as he then was, continued as an M.P. until 1942, when he was elevated to the peerage. In the last Labour Government he was Secretary of State for India. He was in the Yeomanry and the Air Force in the last war, and went back to the R.A.F. at the beginning of the present war, serving first as Squadron-Leader and later holding the post of Director of Public Relations at the Air Ministry with the rank of Air Commodore. Lord Stansgate was Vice-President of the Allied Control Commission for Italy in 1943-44.

Obituary

MR. SIDNEY WILFRED FRANCIS, who died at Buxted, Sussex, on August 3, was managing director of F. Francis & Sons, Ltd., steel drum and tin box manufacturers, Upper Thames Street, London, E.C.4.

New U.S. Anti-Trust Suit

Permutit Companies Named

THE U.S. Government has filed an injunction, and charged the Permutit Co. with participation in an international combine to control production and distribution of water-conditioning apparatus and materials. The suit also names, personally, Mr. S. Robertson, the chairman of the U.S. company, as a defendant, and five foreign companies as conspirators under Anti-Trust Statutes, namely, Permutit Co., Ltd., of London, Permutit A.G. of Berlin, S.A. Etablissements Phillips T. Pain of Paris, a company with the same name in Brussels, and Purificadores de Agua S.A. of Barcelona. The object of the suit is a Court order for the cancellation of international agreements permitting the manufacture under free licence. The Permutit Co. (of Great Britain) carries on business as water purification engineers and manufacturers of water softening plant under Lasen-Hjort patents and "Permutit" and "Zerolit" trade names..

General News——From Week to Week

The official price of copper sheets has been raised by £8 to £109 10s. per ton f.o.b.

Promising discoveries of oil and coal have recently been made in Norfolk.

The Danish steamer *Svanholm* discharged 800 tons of cod-liver oil at Glasgow on August 3. This valuable cargo from Iceland is believed to be one of the largest cargoes of cod oil to enter the country for some time.

The National Association of Wholesale Paint Merchants, inaugurated in London recently, has its offices at Hanover House, 75 High Holborn, W.C.1. The secretary is Mr. Sidney Neve.

The Minister of Supply has released Sir Cecil Rodwell from his appointment as Controller of Industrial Diamonds, and Mr. F. A. Mathias from that of Deputy-Controller. The Industrial Diamonds Control has been disbanded.

Ammonium phosphate remains on the list of goods subject to Middle East Supply Centre procedure. The entry in our last issue (p. 110) concerning this chemical was published in accordance with erroneous information issued by the Board of Trade and since amended.

The Ormskirk Fertiliser Co., Burscough Bridge, Ormskirk, Lancs., has changed its style to Vitax Fertilisers, Ltd. The company's factory is closing for the annual holidays from August 10 to August 20 (exclusive), and no deliveries and correspondence can be dealt with during that period.

By kind permission of the directors of the Manchester Oil Refinery, Ltd., members of the North-Western Branch of the Institution of Chemical Engineers visited the works of that company on July 28. The processes of separating the crude oil into gasoline, kerosene, gas oil, three fractions of lubricating oil and a residue, followed by the further refining of some of the materials by the Edeleanu process, by dewaxing and by chemical treatment, were demonstrated by the company's staff.

Birmabright, Ltd., a component of Birmid Industries, Ltd., which is responsible for the development of the corrosion-resisting medium-strength aluminium-magnesium-manganese alloy pioneered by the Group, has opened a Marine Department at 20 Berkeley Square, London, W.1, with the object of providing information and assistance to naval architects and marine engineers who are interested in aluminium alloy as a material for marine construction. The department will be under the superintendence of Lieut.-Commander F. Merrett, R.N.R., Retd.

Lord McGowan, chairman of I.C.I., has sent a further gift of drugs, valued at £512, to British United Aid to China, on behalf of his firm.

Foreign News

A research station to investigate the cultivation of cinchona is to be set up in Uganda.

Zanzibar mangrove bark has been greatly in demand in the U.S.

Plans are now being actively furthered for the large-scale development of South Africa's vermiculite deposits.

The Metal Reserve Company announces that it will now sell refined copper to all eligible purchasers without certification or authorisation, says Reuter from America.

Notice has been given in the *Tanganyika Gazette* of an application by a firm for a patent for the production of pectin, or pectin substances, from plants of the agave species.

A survey of enemy material from the metallurgical point of view, being a report to the United States War Metallurgy Committee, has recently been issued by the Battelle Memorial Institute, Columbus, Ohio.

The U.S. War Production Board announces that allocation controls on all molybdenum and tungsten products, with the exception of wire, have been removed, thanks to the easing of military requirements.

The inaugural meeting of the non-ferrous metal manufacturers of India was held at the end of June at the Indian Chamber of Commerce at Calcutta to form an All-India Non-Ferrous Manufacturers' Association.

The discovery of two tin-bearing veins in the bedrock at Cape Mountain, in the western part of the Seward Peninsula, Alaska, has considerably enhanced the prospect for the finding of additional reserves of this important strategic ore, reports the director of the U.S. Geological Survey.

Polish zinc ore production is reported to amount at present to about 50,000 tons monthly but it is hoped to increase output to 75,000 tons before the end of the year. Supplies go chiefly to the U.S.S.R., but Sweden, Austria and Hungary are anxious to cover their requirements in Poland.

Two new chemical companies have been granted concessions by the Mexican Ministry of Finance: Química Industrial Marineda, S.A., Gante, will produce sodium arsenate and sodium nitrate, copper and lead arsenates, yellow arsenic sulphide, zinc stearate, sodium methylarsenate, and copper sulphate, while salicylates, phenol, and acetic acid will be made by Salico, S.A., Balderas.

The public telegraph service to Rumania has been restored; and restricted air and surface mail services to Poland are now available (for postcards and letters and printed papers up to 2 oz.)

Commercial production of ammonium thioglycollate solutions in concentrations of 40-45 per cent. has been announced by the Special Chemicals Division of Winthrop Chemical Company, Inc., Rensselaer, N.Y., U.S.A., which has been producing thioglycollic acid for some time.

Surveying the outlook for the U.S. carbon-black industry, the Bureau of Mines says that victory in Europe has brought supply and demand into balance for the first time in two years. Further production increases were scheduled for late this year which may raise the rate of output to more than 110 million pounds monthly.

South Africa should spend at least £1,200,000 a year on industrial research, said Mr. J. E. Worsdale, president of the South African Chemical Institute. He added that the formation, in the near future, of the Council of Scientific and Industrial Research, with Dr. Schonland (of the Bernhard Price Institute of Geophysical Research) as president, will see the beginning of a new era in the Union's economic development.

In Chile, stocks of iron and steel are rapidly disappearing owing to reduced quotas being received from the United States. The tinplate situation is acute. Supply of domestic cement is insufficient. Control over the export of manufactured copper products is being relaxed. Labour disputes involving nitrate plants at Maria Elena and Pedro de Valdivia were settled on the basis of a 5-peso daily wage increase and increases in family allowances.

Production of nickel will start soon at Monchegovsk, on Lake Imandra in the Kola Peninsula, N. Russia. The electrolytic plant is said to be nearly ready. Discovered in the early 'thirties, the mines proved a rich source of nickel before the war, but had to be closed when the Germans invaded the area: however, the equipment was removed in time. The mines were re-opened late in 1942, and the ore shipped to refineries in Siberia.

The development of a new method of extracting petroleum from shale oil is announced by the Socony Vacuum Oil Company. The new process has been put at the disposal of the U.S. Bureau of Mines. The company says that the new method would make available to the United States, when necessary, an estimated 90,000 million barrels of oil, or more than four times the present estimated proven U.S. reserves of natural oil. Deposits of 400,000 million tons of shale oil, principally in Colorado, Utah and Wyoming, could be mined and crushed at a cost of 2.20 dollars per ton.

The establishment of new salterns in Ceylon, to produce about 600,000 cwt. at an economic price, and the creation of brine reservoirs large enough to preserve brine during the wet season, are suggested for after the war by the salt commissioner. There are plans to improve both output and quality, and it is expected that Ceylon will be in a position not only to become self-sufficient as regards supplies of salt, but once again to export it.

Progress on the construction of the 250-ton mercury plant at the Santa Barbara mine in Peru is proceeding slowly on account of the shortage of cement. Although the ore reserves at this mine are large, the average grade is low. The future price of mercury will be the controlling factor in the successful operation of this mine which, according to official reports, had a total production of 1,040,452 Spanish quintals, between 1571 and 1789.

Reports from Peru's non-ferrous metal industries state that in February, 1945, the first test-run precipitates were produced in the new vanadium-leaching plant at Minas Ragra. Capacity of the new installations is 200 tons of ores daily. The old leaching plant with a 100-ton daily capacity has continued to function normally. The Peru Molibdeno S. A., the only important producer of molybdenite concentrates in Peru, resumed milling operations the latter part of last year after a temporary shut-down.

In Brazil, the Companhia Nitro Quimica Brasileira, in the Sao Paulo area, organised in 1935 for the manufacture of nitrocellulose rayon yarn, also produces a number of chemicals for rayon and paint manufacture. These include sulphuric acid, nitric acid, hydrochloric acid, ammonia, anhydrous ammonia, aluminium sulphate, calcium carbonate, sodium thiosulphate (hyposulphite), potassium nitrate, potassium aluminium sulphate, ether, and sulphonated ether. The company also manufactures paints and varnishes and gun cotton. The Companhia Brasileira Rhodiaceta, also near Sao Paulo, produces cellulose acetate for the manufacture of rayon yarn.

The Encyclopedia of Chemical Technology, now in preparation in the United States, will be designed specifically for use in the Americas, according to announcement by the co-editors, Raymond E. Kirk, head of the department of chemistry and dean of the graduate school, and Donald F. Othmer, professor of chemical engineering and head of the department, Polytechnic Institute of Brooklyn. According to Dr. Kirk, no encyclopedia of chemical technology in the English language exists; the only equivalent to the proposed work at present available is a German encyclopedia. It is proposed that the new encyclopedia will be a 10- or 12-volume set, and the first volume is scheduled to appear in April next.

Sales of bromine compounds by primary producers in the U.S. established a record in 1944, according to the Bureau of Mines. Sales of contained bromine amounted to 102,112,462 lb., an increase of 9 per cent. over 1943. The increase was due largely to expanded production of ethylene dibromide for use in anti-knock compounds.

A rayon industry for India is now under consideration by the Indian Government together with expansion of the plastics and alkali industries. Dr. K. L. Ramaswamy, deputy general manager of Mysore Chemicals and Fertilisers, Ltd., who, with Mr. T. N. Rao, chief engineer of the company, has just completed a tour of the United States and Canadian chemical plants, said he expected that the rayon industry would be started on a small scale to supply only the home market and added that home consumption should be considerable. Several plastic plants, including the one he represented, were manufacturing the moulded products and importing their raw materials from Britain, although some plants were making their own formaldehyde.

Commercial Intelligence

The following are taken from printed reports, but we cannot be responsible for errors that may occur.

Satisfaction

PRESSURE LUBRICANTS, LTD., London, E.C. (M.S., 11/8/45.) Satisfaction July 19, of debenture registered August 31, 1942.

Company News

The Dow Chemical Co. reports net sales, for the year to May 31, of $124,570,200 ($120,426,591). Net income was $8,738,761 ($8,573,503).

W. J. Bush & Co., Ltd., report a net profit, for 1944, of £129,583 (£128,887). Final dividend of 6 per cent. makes a total of 10 per cent. (same). Forward, £170,528 (£135,911).

Hugh Newsome & Co., Ltd., chemical manufacturers, Southport, have increased their nominal capital, beyond the registered capital of £400, by the addition of £1100 in 1100 5 per cent. cumulative preference shares of £1 each.

George Kent, Ltd., are paying a final ordinary dividend of 7½ per cent. for the year ended March 31, plus 2½ per cent. bonus, making 12½ per cent. (same). Net profit was £29,743 (£32,944); forward, £39,887 (£37,569).

Ashe Laboratories, Ltd., 120 Victoria Street, S.W.1, have increased their nominal capital, beyond the registered capital of £20,000, by the addition of £10,000 in 10,000 6 per cent. preference shares of £1 each, ranking *pari passu* with existing preference shares.

The United Premier Oil and Cake Co., Ltd., reports a gross income of £192,834 (£243,534). Net profit amounts to £36,910 (£36,982). A final ordinary dividend of 8⅓ per cent., makes again a total of 15 per cent.

Metal Industries, Ltd., with a final dividend of 6 per cent. (same) on "A" and "B" ordinary stock, have made a total distribution, for the year ended March 31, of 9 per cent. (8½ per cent.)

New Companies Registered

Vitax Fertilisers, Ltd. (397,383.)—Private company. Capital £15,000 in £1 shares. Manufacturers of and dealers in fertilisers, etc. Directors: E. Hellewell, Homestead, Junction Lane, Burscough; E. W. Hutchinson.

Calcium Contractors, Ltd. (397,201.)—Private company. Capital £100 in 1000 2s. shares. Manufacturers of and dealers in fertilisers, animal feeding stuffs, lime, chalk, cement, magnesite, etc. Subscribers: H. A. Smith (first director); Mrs. C. A. Smith. Registered office: Barton Cutting, Barton-in-the-Clay, Beds.

Sherbourne Plating Co., Ltd. (397,381.)—Private company. Capital £2500 in £1 shares. To acquire the business of an electro-plater and enameller carried on by J. H. Saunders at Coventry, as the "Sherbourne Plating Co." Directors: J. H. Saunders, H. J. Saunders, Edith M. Saunders. Registered office: 9a Lower Ford Street, Coventry.

Marino Process, Ltd. (397,100).—Public company. Capital £10,000 in 10,000 £1 shares. To acquire rights for Great Britain and Canada of a process for electro-galvanising iron and steel articles, and to carry on the business of chemical, marine, mechanical and general engineers. Subscribers: P. G. Marino, S. E. Bramwell and five others. Registered office: Sun Building, Bennetts Hill, Birmingham, 2.

Chemical and Allied Stocks and Shares

SELLING has been less in evidence, but on balance values have recorded further sharp declines as compared with a week ago, although the lower prices attracted buyers. The widespread nature of the setback in industrial shares was due partly to the fact that there was a general tendency to follow a cautious policy of taking profits on industrials and reinvesting in gilt-edged stocks. This partly accounts for the firm undertone in British Funds. Many investors purchased industrial shares in the past few years at prices considerably below those now ruling. The tendency has been to await the opening of Parliament and the King's Speech

on Wednesday for information as to the intentions of the Government and the scope of the nationalisation policy.

Reflecting the surrounding trend, shares of chemical and allied companies have declined further on balance. Imperial Chemical at 35s. 10½d. (after 35s.), compared with 37s. 9d. a week ago, now yield 4½ per cent. Lever & Unilever have fallen from 46s. 3d. to 43s. 1½d., and Turner & Newall from 78s. 9d. to 73s. 9d. The lower prices attracted better demand in some cases, and Dunlop Rubber after 44s. 9d. rallied to 46s. 3d., which, however, compared with 48s. a week ago. Boots Drug at 50s. 7½d., British Aluminium at 41s. 9d., Sangers at 30s. 6d., and United Molasses at 38s. 3d., were also above the lowest levels recorded since the Election result. Although again mostly lower on balance, iron and steel shares also recorded a small rally, Consett Iron at 8s., Staveley at 44s., and Stewarts & Lloyds at 47s. 3d., rallying a few pence. Compared with a week ago, however, some declines were substantial, Allied Ironfounders being 48s. 3d., against 51s. 3d., Guest Keen 36s. 4½d. against 38s. 6d., and Dorman Long 23s. 6d. compared with 26s. 3d.

Textiles also moved back again, but in some cases prices were above the lowest of the past few days. Dividend prospects of many textile shares will turn in a large measure on the new Government's policy in regard to E.P.T. The latter bears heavily on many textile companies, and there had been a steady rise this year in textile shares on hopes of the eventual abolition of E.P.T. Bradford Dyers were 24s., compared with 25s. a week ago, Fine Spinners 21s. 9d. compared with 22s. 6d., Bleachers 11s. 9d. compared with 12s. 6d., and Calico Printers 17s. 6d. against 18s. Elsewhere, British Plaster Board have declined further on balance from 36s. 3d. to 34s. 3d., Associated Cement from 58s. to 55s., Crittalls from 27s. 3d. to 24s. 6d., and British Oxygen from 83s. 9d. to 76s. 3d. The units of the Distillers Co. were 110s., a further decline of 2s. 6d. on balance, while at 87s. 6d. Metal Box shares were 3s. 9d. below the level of a week ago.

B. Laporte at 85s. 6d. were little changed on balance, while Greeff-Chemicals Holdings 5s. ordinary remained around 9s. In other directions W. J. Bush shares kept steady on the results and the unchanged 10 per cent. dividend. Shares of the latter company were as usual firmly held and consequently it was doubtful whether the quotation was adequately tested. Monsanto Chemicals 5 per cent. preference remained at 23s. Amalgamated Metal declined further from 19s. to 16s. 6d., Imperial Smelting from 15s. to 13s. 6d. (after 13s.), and Murex from 96s. 3d. to 91s. 3d. Borax Consolidated deferred at 41s. were 1s. below the level of a week ago. Oil shares subsequently became steadier, but have reflected the downward trend of markets, "Shell" being 78s. 9d. against 81s. 3d. a week ago, Anglo-Iranian 105s. compared with 108s. 9d., and Burmah Oil 78s. 1½d. compared with 81s. 3d.

British Chemical Prices

Market Reports

SEASONABLY quiet conditions are in evidence in the London general chemicals market although deliveries against contracts are well up to schedule. Additions to order books have not been extensive but a fair amount of fresh inquiry has been reported. In the soda products section a steady inquiry is in evidence for both grades of hyposulphite of soda, and a good demand is reported for acetate of soda, Glauber salt and salt cake. There is no improvement in the supply position of yellow prussiate of soda, while supplies of industrial refined nitrate of soda are moving steadily into consumption. Bicarbonate of soda is a good market. The potash chemicals generally are in short supply, with offers of caustic potash and bichromate of potash finding a ready outlet. Business in acid phosphate of potash has been on steady lines. Trade in coal-tar products is quiet and little export business has been transacted, chiefly owing to the shipping position. Pitch is being absorbed in fair quantities and there is a steady demand for crude tar. The benzols and toluols are active, and a fair trade is passing in the xylols and naphthas.

MANCHESTER.—With the holiday season now at its height and a large number of textile and other industrial users in Lancashire under its influence, activity on the Manchester chemical market during the past week has continued to be affected. Although still of fair extent in the soda compounds and other bread-and-butter lines of chemicals, deliveries generally against contracts have been of smaller volume and there has also been a contraction in the flow of inquiries and new bookings. For the most part trade in fertilisers has been at a seasonally low level, although an early revival is now looked for.

GLASGOW.—Activity in the Scottish heavy chemical trade has been moderate during the past week for home business. Export inquiries continue to be received regularly. Prices remain firm with increases in some instances.

SITUATIONS VACANT

None of the situations advertised in these columns relates to a man between the ages of 18 and 50 inclusive or a woman between the ages of 18 and 40 inclusive, unless he or she is excepted from the provisions of the Control of Engagement Order, 1945, or the vacancy is for employment excepted from the provisions of that Order.

NEWCASTLE-UPON-TYNE AND GATESHEAD GAS COMPANY

ASSISTANT MANAGER — TAR AND BENZOL WORKS

APPLICATIONS are invited for the above position. Duties to include, under Works Manager, operation and upkeep of plant, control of labour, supervision of constructional work and allied duties. Applicants should state experience, chemical and chemical-engineering qualifications, age and present employment.

References should be given.

Commencing salary not less than £600 basic plus war bonus (at present about 12 per cent.) according to qualifications.

Excellent prospects.

Apply—Chief Engineer, 30, Grainger Street, Newcastle-upon-Tyne, 1.

SITUATIONS VACANT

INTELLIGENT man required to take charge of production of Waxes and Crayons on small scale plant. Excellent prospects. Write giving age, experience (in detail) and salary required. Box No. 2227, THE CHEMICAL AGE, 154, Fleet Street, London, E.C.4.

QUALIFIED CHEMIST required for old-established Firm of Cable Manufacturers in the London Area to take charge of the Paper Cable Laboratory. In addition to supervising the routine work of the Laboratory, applicants must be capable of undertaking investigational and development work and of dealing with various chemical problems arising in power cable construction, installation and operation. Sound experience in the technique of cable practice is essential and preference will be given to applicants familiar with high voltage applications. Age about 30-35. Commencing salary £400-£500 according to qualifications and experience. Participation in the Company's superannuation scheme is a condition of employment becoming effective after one year's service. Applications will be treated as strictly confidential and should give full details of education, training, and qualifications and complete record of all previous experience. Box No. 2229, THE CHEMICAL AGE, 154, Fleet Street, London, E.C.4.

WANTED

WANTED—Rubber Mill, steam heated rolls 10/12 in. dia., 12/16 in. long, friction drive. Reply Box No. 2230, THE CHEMICAL AGE, 154, Fleet Street, London, E.C.4.

WANTED.—Supplies of Nitre Cake in ten-ton lots, Box No. 2126, THE CHEMICAL AGE, 154, Fleet Street, E.C.4.

WANTED—48/60 in. Rubber Calenders. Reply Box No. 2228, THE CHEMICAL AGE, 154, Fleet Street, London, E.C.4.

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this paper should not be taken as an indication that they are necessarily available for export.

Printed in Great Britain by THE PRESS AT COOMBELANDS, London and Addlestone, and published by BENN BROTHERS, LTD., at Bouverie House, 154, Fleet Street, E.C.4, August 11th, 1945. Entered as Second Class Matter at the New York, U.S.A., Post Office.